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PREDICTING EFFICIENCY OF SITUATIONAL PISTOL SHOOTING ON THE BASIS OF MOTOR ABILITIES OF THE STUDENTS OF ACADEMY OF CRIMINALISTIC AND POLICE STUDIES

Goran Vučković & Milivoj Dopsaj

Department of Special Physical Education, Academy of Criminalistic and Police Studies, Belgrade, SERBIA

Abstract This paper aims to evaluate the connection of successfulness, as a value of efficiency of use of fire-arms under specific police situations, and the motor abilities of the students of the Belgrade Academy of Criminalistic and Police Studies (ACPS). Testing sample included 108 students (males) of the 2^{nd} year of ACPS, age 19 to 21. The sample of predicting variables consisted of a set of 34 motor variables, while the criterion variable was represented by the efficiency in use of fire-arms at the pistol shooting range where the lifting of targets is directed ($RB1_{effic}\%$). Regarding the statistic methods, we have used the method of descriptive statistics and the method of multiple regression analysis (MRA). The results of MRA show that 11.79% of criterion space can be explained with statistic significance ($F_{ratio} = 2.10$; $p = 0.021$) by the model of chosen predicting variable (adj $R^2 = 11.79\%$). In other words, the results show that 11.79% of efficiency of shooting out of hand fire-arms depends, in this case, on the motor abilities represented by physical characteristics of contractile abilities of the tested muscle groups, maximal locomotion speed, aerobic fitness, general energetic efficiency of body functions under effort and specific pistol handling skill. The results showed that calculated function of equation mathematical model of predicting efficiency of fire-arms use at the situational pistol polygon as: $RB1_{effic}\% = -1687.42 - 71.7163 * VO2_{rel} + 1314.52 * V_{crit} - 11.6907 * ENERG_{effic} - 40.6152 * Dead_{LIFT}F_{max30\%} + 12.0859 * Dead_{LIFT}F_{max100\%} - 0.0231605 * Dead_{LIFT}RFD_{30\%} + 262.489 * RUN_{20m} + 1.98107 * MANIP_{weap} + 0.0332351 * Dead_{LIFT}RFD_{50\%} + 0.0248511 * LEGSRFD_{30\%} - 0.0261059 * LEGSRFD_{50\%} + 0.0976722 * HG_RRFD_{100\%} - 0.0156211 * HG_LRFD_{50\%}$, with standard estimation error of ± 17.74% of fire-arms using efficiency.

Key words: police, efficiency of shooting, situational pistol shooting, motor abilities

INTRODUCTION

The use of modern technical devices has not eliminated human factor while solving and executing the most complex jobs and tasks within the field of activities of the Ministry of Interior Affairs. Human factor as professionally dominant requires a high level of motor (physical) ability of an individual as one of the prerequisites for successful performance of professional tasks.

In the course of education of the students of Academy of Criminalistic and Police Studies (ACPS) and their preparation for execution of professional tasks, in addition to theoretical, specific technical and tactical knowledge, great consideration is given to improving their motor abilities. This is why the teaching subject Special Physical Education (SPE) includes also, in addition to general preparatory means and methods, the tasks aiming at training the students to use weapons in specific professional situations. Current needs and development trends in SPE also require a greater need for multidisciplinary approach to improvement of training, general and special physical preparation, as well as technical and tactical training and fitness of the students.

One of the segments of special physical fitness and technical and tactical training of students is also the capability to efficiently solve the complex situations which require the use of weapons. This is why the Situational Police Shooting Polygon (SPSP) has been made within the automatic shooting range 'Paklenik', where the conditions have been created to exercise and adopt the said capabilities in situations close to realistic ones [13]. The structure of the range is made in such a way that the students are required to complete the polygon tasks successfully crossing over natural and artificial barriers and use hand fire-arms at the same time (Figure 1).

Police officers are often the target of criminal attacks and during such attacks fire-arms or mines or other explosives are more and more frequently used. In these situations the police officers are forced to respond to the attack using coercive measures, often using the ultimate coercive measure, fire-arms. These situations must be solved with added, increased psycho-physical and motor efforts where the level of fitness and tolerance to the physical effort and stressful situations are the factors that condition the efficiency of realization in such a situation [1, 16, 27].

This paper aims at evaluating the connection of successfulness, as a value of efficiency of use of fire-arms under specific police situations, and the motor abilities of the students of ACPS. After that, based on the framework and structure of the connection between predictors and criteria and using mathematical modelling, the regression equation of predicting criteria will be defined, i.e. the successfulness in solving situational pistol polygon, as a measure of efficiency of the use of hand fire-arms in specific police situations. In this way, first of all, we shall come to some new knowledge about the connection between both spaces which will accordingly provide the conditions for continuing the improvement of the educational process at academy using reliable prognostic measures, but the new knowledge will also contribute to the continued improvement of technological process of SPE within the Ministry of Interior Affairs (selection, training, checking the level of capability, etc.).

MATERIAL AND METHODS

SUBJECTS SAMPLE

The subjects sample included 108 students (male) of the 2nd year of Academy of Criminalistic and Police Studies in Belgrade, age 19 to 22. The basic morphological characteristics of the sample were: BH = 1.811 ± 0.0041 meters; BM = 80.01± 8.53 kg.

VARIABLES SAMPLE

The sample of predicting variables consisted of a set of 34 motor variables, while the criterion variable was represented by the efficiency in the use of fire-arms at the pistol shooting range where the lifting of targets is directed. All motor variable testing was carried out two weeks before the end of the summer class semester (last two weeks in May 2004). All motor testing was carried out by professors of SPE, using standard physical exam testing technology and procedure of testing, very familiar to all the students, while SPSP was carried out in the third week of June 2004, during the summer ACPS practice.

We took those motor variables which have been proven in the researches done so far to cover the space of importance for motion structure dominating in professional tasks of the police [2, 5, 14, 15, 29], as well as the tests which are used today when testing basic physical characteristics of sportsmen but are also applied in police testing. [7, 8, 30].

PREDICTING VARIABLES

Predicting variables are represented by 34 individual variables, 24 of which describe contractile abilities of tested muscle groups (back-waist extensor musculature, leg extensors and left- and right-hand finger flexors), and in relation to the maximum force (F_{max}) and rate of force development (RFD) to 30%, 50% and 100% of F_{max}.

In this case all the observed force characteristics realized for 30% of maximum force define contractile potential of Stretch Shorten Cycle (SSC), i.e. contractile force potential which may be realized within 250 ms time interval [23].

Contractile force characteristics realized for 50% of maximum force define contractile potential connected to starting acceleration (S-gradient) of movement performance, i.e. they represent the indicator of specific explosiveness, while the contractile potential of realized force of 100% represents the indicator of general (basic) explosiveness [31].

The remaining 10 variables represent the space of repetitive force, locomotion speed, body energetic potential and specific physical abilities of policeman [2, 14, 16, 29].

CONTRACTILE MUSCLE CHARACTERISTICS

Among contractile muscle characteristics, we observed the abilities which define the level of achieved force and the rate of force development (RFD) at 30%, 50% and 100% of F_{max}, realized in isometric condition at four muscle groups: back-waist extensors (isometric dead lift test) and leg muscles (isometric legs extension test from standing position), and left- and right-hand flexors (hand grip test) [7, 8, 30].

1. Value of *isometric muscle force* of back-waist extensors musculature at the level of 30%, 50% and 100% of F_{max} ($Dead_{LIFT}F_{max30\%}$, $Dead_{LIFT}F_{max50\%}$ and $Dead_{LIFT}F_{max100\%}$), expressed in N,
2. Value of *isometric RFD* of back-waist extensors musculature, at the level of 30%, 50% and 100% of F_{max} ($Dead_{LIFT}RFD_{30\%}$, $Dead_{LIFT}RFD_{50\%}$ and $Dead_{LIFT}RFD_{100\%}$), expressed in N/s,
3. Value of *isometric muscle force* of leg extensors at the level of 30%, 50% and 100% of F_{max} ($LEGSF_{30\%}$, $LEGSF_{50\%}$ and $LEGSF_{100\%}$), expressed in N,
4. Value of *isometric RFD* of leg extensors at the level of 30%, 50% and 100% of F_{max} ($LEGSRFD_{max30\%}$, $LEGSRFD_{max50\%}$ and $LEGSRFD_{max100\%}$), expressed in N/s,
5. Value of *isometric muscle force* of left hand grip at the level of 30%, 50% and 100% of F_{max} ($HG_LF_{max30\%}$, $HG_L F_{max50\%}$ and $HG_L F_{max100\%}$), expressed in N,
6. Value of *isometric RFD* for left hand grip at the level of 30%, 50% and 100% of F_{max} ($HG_LRFD_{max30\%}$, $HG_LRFD_{max50\%}$ and $HG_LRFD_{max100\%}$), expressed in N/s,
7. Value of *isometric muscle force* of right hand grip at the level of 30%, 50% and 100% of F_{max} ($HG_RF_{max30\%}$, $HG_RF_{max50\%}$ and $HG_RF_{max100\%}$), expressed in N,
8. Value of *isometric RFD* for right hand grip at the level of 30%, 50% and 100% of F_{max} ($HG_RRFD_{max30\%}$, $HG_RRFD_{max50\%}$ and $HG_RRFD_{max100\%}$), expressed in N/s.

For all the tested muscle groups laboratory equipment for measuring contractile characteristic was used. Besides the force parameters, we also measured time parameters in miliseconds. In this way, for every single isometric muscle test we had a full F-t relation, all force and time data, from zero point (0% of F_{max}) to maximum point (100% of F_{max}) for every 1 % of F-t changes [7, 8].

INDICATORS OF SPEED AND REPETITIVE STRENGTH

As far as speed strength and repetitive strength indicators are concerned, we used the tests which define the contractile potential realized in repetitive mode in the zone of maximum effort on the arms extensors and flexors, leg extensors and abdominal flexors:

1. Number of push-ups within 10 seconds ($PUSH_{UPS}10$), expressed in number,
2. Number of bent–knee sit-ups with rotation to the left and right side within 30 seconds ($SIT_{UPS}30$), expressed in number,
3. Number of pull-ups on the hand bar within 10 seconds ($PULL_{UPS}10$), expressed in number,
4. Standing double legs long jump ($LONG_{JUMP}$), expressed in cm.

LOCOMOTION (RUNNING) SPEED

Locomotion speed was defined by the tests for the evaluation of absolute maximum running speed, as well as maximum running speed in aerobic mode of body effort:

1. Running speed at 20 meters with flying start (RUN_{20m}), expressed in seconds,
2. Critical aerobic running speed (V_{crit}) – as a value of preparedness for maximum intensity running efforts realized in aerobic mode of body strain [14], where the given value of the critical aerobic running speed was obtained by applying the mathematical modelling of Distance – Time ratio by linear regression method, calculated from the RUN_{20m} and Cooper 12 min running test results, expressed in m/s.

ENERGETIC BODY POTENTIALS

Energetic body potentials were evaluated by aerobic power indicators as well as by coefficient of general efficiency of body functioning from the aspect of power and mechanics of movement:

1. Aerobic power evaluated by relative value of aerobic energy potential of the body (VO_{2rel}), calculated indirectly from Cooper 12 min running test results using by the following equation [14]:

$$VO_{2rel} = 3.134304 \cdot 10^{-7} \cdot X^2 + 0.02077344 \cdot X - 9.03125 \quad (1)$$

- Where: VO_2rel – is relative values of aerobic power, expressed in ml/kg/min [3, 22]; X - is Cooper 12 min running test results, expressed in meters.

2. Energetic efficiency of body functioning under aerobic efforts ($ENERG_{effic}$),

$$ENERG_{effic} = \frac{V_{crit}}{RUN_{20m}} \times 100 \quad (2)$$

- Where: $ENERG_{effic}$ – energetic efficiency of body functioning under aerobic efforts, expressed in arbitrary units [14]; V_{crit} - is critical aerobic running speed, expressed in m/s; RUN_{20m} - Running speed at 20 meters with flying start, expressed in m/s.

3. Mechanical efficiency of body functioning under aerobic efforts ($MECHAN_{effic}$).

$$MECHAN_{effic} = V_{crit} / VO_{2rel} \quad (3)$$

- Where: $MECHA_{effic}$ – is mechanical efficiency of body functioning under aerobic efforts, expressed in arbitrary units [14]; V_{crit} - is critical aerobic running speed, expressed in m/s; VO_2rel – is relative values of aerobic power, expressed in ml/min/kg [3, 22]; X - is Cooper 12 min running test results, expressed in meters.

Specific Dexterity

Specific dexterity was evaluated on the basis of the test for evaluation of basic weapon (official Serbian police pistol – CZ 99) manipulation ability [4]:

1. Basic weapon manipulation ($MANIP_{weap}$), expressed in seconds.

Criterion Variable

Criterion variable represented the result expressed as the efficiency of target strike down at the situational shooting range ($RB1_{effic}$%) when the target lifting is directed [13].

Shooting Range Obstacles and Targets

There are eight obstacles set on the shooting range, made of wood, metal and concrete. They are: horizontal bar, wooden fence, pipe, climbing grid, stumps and wall. The size of obstacles and the manner of surmounting them is as follows:

- Horizontal bar, 2.2 meters high; surmounted by a spin hanging on a back of the knee or with a swing,
- Wooden fence, 1.5 meters high: surmounted by side summersault
- Pipe, 0.8 m in diameter and 1.2 meters long; surmounted by crawling through it
- Arch climbing grid, 3 meters high and 6 meters long; surmounted by alternate hand hanging grasps,
- 4 stumps; overcome by zigzag running,
- Wall, 1.5 m high; surmounted by crouches with front and one leg support,
- Window.

There are four lines of targets set at the shooting range; the first line having one target, the second having two targets, the third having three targets and the fourth line having one target. The maximum number of targets on this tactical path is 7. The first line of targets is set at the distance of 37 meters from the starting line, the second line of targets is set at the distance of 70.5 meters; the third line of targets is at the distance of 101 m and the fourth at the distance of 116 m from the starting line [13].

The distance of target lines and the fire line is 8.5 m for the first and third fire line, 6.5 m for the second and 11 m for the fourth fire line. The targets were front running, size 1 x 0.5 m (Figure 2).

SHOOTING POSTURES

While solving the SPSP the students used the following shooting postures: standing two-hand posture – Weaver posture which is taken at the first fire line [17]; then at the second fire line they took standing posture for instinctive shooting from the hip by one hand where the pistol barrel is within the sight of the shooter as well as the targets for possible fire correction [26]. The shooters took a one-knee kneeling position holding the weapon with both hands on the third fire line, and on the fourth fire line they took the posture of lying prone and holding the gun with both hands [26].

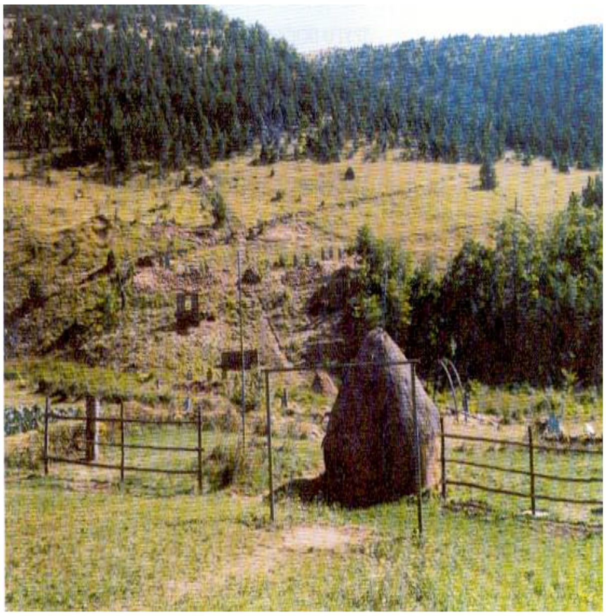

Figure 1. The polygon 'Paklenik' - the natural and artificial barriers for testing situational pistol shooting efficiency

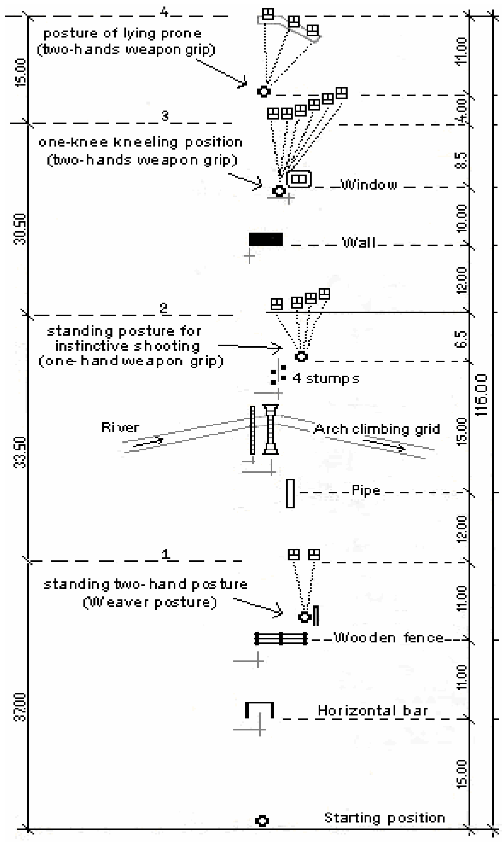

Figure 2. The situational pistol shooting obstacles

STATISTICAL METHODS

Regarding the statistic methods, we used the method of descriptive statistics and the method of multiple regression analysis (MRA) with backward elimination criterion. We used MRA for a variable selection for purpose of finding the best tested variable combination for the highest possible explanation of criterion variable, i.e. efficiency of situational pistol shooting [25].

The descriptive statistics was used to calculate the following parameters: arithmetic mean ($\overline{X}$), standard deviation (SD), coefficient of variation (cV%). The MRA is used in order to determine statistic importance of the variability influence of the system of predicting variables on the description of criterion variable variability over coefficient of determination (R^2).

All analyses were made by IBM compatible PC using statistic software program SPSS for Win, release 7.5.1 – Standard Version (Copyright © SPSS Inc., 1989-1996).

RESULTS

Table 1 shows the descriptive statistics of the observed variables.

Table 1. Basic descriptive statistics

		Variables	***MEAN***	***SD***	***cV%***
Contractile isometric muscle characteristics	Back-waist extensors muscles	$Dead_{LIFT}F_{max30\%}$ (N)	502.78	63.34	12.61
		$Dead_{LIFT}F_{max50\%}$ (N)	837.01	105.67	12.63
		$Dead_{LIFT}F_{max100\%}$ (N)	1672.67	211.47	12.65
		$Dead_{LIFT}RFD_{30\%}$ (N/s)	7439.78	4039.88	54.26
		$Dead_{LIFT}RFD_{50\%}$ (N/s)	5836.92	3317.43	56.84
		$Dead_{LIFT}RFD_{100\%}$ (N/s)	827.24	386.78	46.76
	Leg extensors muscles	$LEGSF_{max30\%}$ (N)	501.91	78.54	15.64
		$LEGSF_{max50\%}$ (N)	835.56	130.67	15.65
		$LEGSF_{max100\%}$ (N)	1669.73	261.33	15.65
		$LEGSRFD_{30\%}$ (N/s)	6919.43	3508.90	50.71
		$LEGSRFD_{50\%}$ (N/s)	5767.18	2898.05	50.25
		$LEGSRFD_{100\%}$ (N/s)	974.20	498.01	51.12
	Left hand grip muscles	$HG_LF_{max30\%}$ (N)	175.39	26.89	15.36
		$HG_LF_{max50\%}$ (N)	290.55	44.67	15.39
		$HG_LF_{max100\%}$ (N)	579.72	89.90	15.51
		$HG_LRFD_{30\%}$ (N/s)	6495.18	3656.22	56.29
		$HG_LRFD_{50\%}$ (N/s)	4342.14	2046.89	47.14
		$HG_LRFD_{100\%}$ (N/s)	772.18	457.43	59.24
	Right hand grip muscles	$HG_RF_{max30\%}$ (N)	189.33	29.45	15.61
		$HG_RF_{max50\%}$ (N)	313.45	49.11	15.65
		$HG_RF_{max100\%}$ (N)	625.41	97.67	15.63
		$HG_RRFD_{30\%}$ (N/s)	4855.78	3055.78	69.55
		$HG_RRFD_{50\%}$ (N/s)	4069.55	2189.50	57.57
		$HG_RRFD_{100\%}$ (N/s)	763.12	383.13	52.43
Repetitive strength		$PUSH_{UPS}10$ (number)	12.31	1.50	12.19
		$SIT_{UPS}30$ (number)	28.39	2.44	7.90
		$PULL_{UPS}10$ (number)	5.69	1.54	27.00
		$LONG_{JUMP}$ (cm)	233.05	12.84	5.51
Locomotion (running) speed		RUN_{20m} (m/s)	7.69	0.46	5.92
		V_{crit} (m/s)	4.21	0.23	5.36
Energetic body potentials		VO_{2rel} (ml/kg/min)	53.46	3.65	6.83
		$ENERG_{effic}$ (arbitrally units)	54.91	3.62	6.60
		$MECHAN_{effic}$ (arbitrally units)	78.90	1.12	1.41
Specific dexterity		$MANIP_{weap}$ (s)	7.02	1.36	19.34
Criterion variable		$RB1_{effic}\%$ (%)	59.78	18.89	31.59

Table 2 shows the results of multiple regression analysis for variables which by regression model, method of backwards elimination, defined the model of mathematical regression equation. By this model we extracted the set of 13 variables which make the complex of space of motor characteristics that, integrally and on the statistically significant level, describes criterion variable (RB1effic%).

Table 3 shows the results of ANOVE regression. The results show that the separated set of 13 predicting variables statistically significantly describes the criterion variable at the level $p=0.021$. The model explains 11.79% of criterion variability with standard estimation error of ± 17.74% of fire-arms using efficiency. It can be considered that the calculated model is useful and quite reliable since the value of standard estimation error (Standard Error of Estimate – 17.74%) is lower than the standard error (SD) criterion (Table 1 – SD RB1effic% = 18.89%).

Table 4 shows the function of equation of mathematical model of predicting efficiency of fire-arms use at the SPSP.

Table 2. Multiple regression analysis of defined model of mathematical regression equation

The multiple regression analysis model				
Variables	Nonstandardized Coefficients B	Stand. Error	t values	p significance
$Dead_{LIFT}RFD_{50\%}$	0.033	0.011	2.915	0.004
$Dead_{LIFT}RFD_{30\%}$	-0.023	0.010	-2.328	0.022
$LEGSRFD_{30\%}$	0.025	0.011	2.197	0.030
$HG_{R}RFD_{100\%}$	0.098	0.045	2.155	0.034
$LEGSRFD_{50\%}$	-0.026	0.014	-1.886	0.062
$Dead_{LIFT}F_{max30\%}$	-40.615	25.402	-1.599	0.113
V_{crit}	1314.52	828.314	1.587	0.116
$Dead_{LIFT}F_{max100\%}$	12.086	7.619	1.586	0.116
$MNIP_{weap}$	1.981	1.307	1.516	0.133
VO_{2rel}	-71.716	47.814	-1.450	0.137
RUN_{20m}	262.489	207.156	1.267	0.208
$ENERG_{effic}$	-11.691	9.761	-1.198	0.234

Table 3. The results of ANOVE regression.

R^2	22.51				
adjusted R^2	11.79				
Standard Error of Estimate	17.74				
Mean Absolute Error	13.48				
Analysis of Variance					
Source	Sum of Squares	Df	Mean Square	F-ratio	p-value
Model	8592.52	13	660.96	2.10	0.021
Residual	29579.90	94	314.68		
Total	38172.40	107			

Table 4. Function of equation of mathematical model of predicting efficiency of fire-arms use at the SPSP.

Model predicting equation

$$RB1_{effic}\% = -1687.42 - (71.7163 * VO_{2rel}) + (1314.52 * V_{crit}) - (11.6907 * ENERG_{effic}) - (40.6152 * Dead_{LIFT}F_{max30\%}) + (12.0859 * Dead_{LIFT}F_{max100\%}) - (0.0231605 * Dead_{LIFT}RFD_{30\%}) + (262.489 * RUN_{20m}) + (1.98107 * MANIP_{weap}) + (0.0332351 * Dead_{LIFT}RFD_{50\%}) + (0.0248511 * LEGSRFD_{30\%}) - (0.0261059 * LEGSRFD_{50\%}) + (0.0976722 * HG_{R}RFD_{100\%}) - (0.0156211 * HG_{L}RFD_{50\%})$$

Discussion

The results of regression analysis (Table 3) show that 11.79% of criterion space can be explained by the model of chosen predicting variable (adjusted determination coefficient = adjusted R^2 - 11.79), i.e. the efficiency of fire-arms use at the SPSP when the lifting of targets is directed ($RB1_{effic}\%$). In other words, the results show that 11.79% of the efficiency of shooting out of hand fire-arms depends, in this case, on the motor abilities represented by physical characteristics of contractile abilities of the tested muscle groups, locomotion speed, aerobic fitness, general energetic efficiency of body functions under effort and specific dexterity. Unexplained common variability of 88.21% or 4/5 of total variability is part of what can hypothetically be attributed to other factors such as: psychological space (perceptive, conative, cognitive, motivational, etc. characteristics of the examinees), hormonal-neural level (resistance, adjustability and speed of recovery from stress), the level of being well-trained for the use of fire-arms on the polygon, previous experience in the use of fire-arms, technical errors during performance, total measurement errors of given variables and the like [16].

Among the predicting variables of the defined mathematical model which are statistically significant at the level higher than 90% and which describe the criterion only for those contractile muscle abilities which control the mechanisms for regulation of the realized force intensity were ($Dead_{LIFT}RFD_{30\%}$, $Dead_{LIFT}RFD_{50\%}$, $LEGSRFD_{30\%}$, $LEGSRFD_{50\%}$, $HG_{R}RFD_{100\%}$ - Table 2).

The average time interval required to realize the force of the appropriate intensity for the tested sample for variables $Dead_{LIFT}RFD_{30\%}$ and $LEGSRFD_{30\%}$ was 93.98 and 95.86 milliseconds respectively, for variables $LEGSRFD_{50\%}$ and $Dead_{LIFT}RFD_{50\%}$ it was 187.88 and 203.99 milliseconds respectively, and for variable $HG_{R}RFD100\%$ it was 1011.11 milliseconds.

Successful solving of the motor tasks required adequate response expressed by performance of the appropriate move (selected reaction) in the function of realization time (time adjustment) [19]. The motor processes are controlled via CNS in the areas of pre-motor and primary motor cortex [10, 12, 19, 21, 24]. Each individual movement, whether it is a fine and precise movement of a single finger [24], coordinated movement of certain pairs of fingers or all fingers [10, 12], keeping certain body parts in balance [21] or it is a motor task related to various kinds of reactions to stimuli and the possibility of multiple choice [19] is specifically controlled by the area competent for the motor control in cortex.

The mechanism of performance of motor action is subordinated by the established motor programs on the basis of which the motor task is controlled and corrected through a closed system which approximately lasts for 120 milliseconds [21]. The control and actual correction of the motor task is done on the basis of sensory processes by parallel processing of data by the sense of vision, hearing or tactile sense, where the time of motor realization or correction of posture depend on the quantity of information and the complexity of choice for the solving of a task [19]. The subsequent correction of motor action or posture of the whole body or part of the body is made on the basis of additional production of muscle force (producing restoring forces) as a consequence of appropriate contractions of the muscles in order to achieve the desired/needed movement, i.e. motor act [21].

Depending on the individual evaluation of solving the motor situation, the posture correction is made based on the use of the mechanisms for controlling of the intensity of explosive muscle force. It has been established that the explosive force production, i.e. the higher grade of RFD of leg extensors statistically significantly describes the speed of gaining the balance position after unexpected disruption of balance position of a male individual. Such a connection is especially significant during 500 ms time interval [9].

The research done by Gianikellis and associates [6] confirms the high statistic significance relation between the efficiency of shooting into the fixed target and the parameters which define the stability of position of the lower part of the body (legs). This relation is especially intensified during the time interval prior to discharge (1.5 to 2 seconds), i.e. in the situation when the trigger is being pulled. This research actually proves the great significance of the control of small body oscillations present during aiming, prior and during discharge. It is this ability of efficient control, i.e. neutralizing unnecessary big weapon oscillations in sagittal and front plane that is the dominant factor determining elite from intermediate biathlons during shooting, and especially in the state of competitors' fatigue [20].

In relation to the efficiency of shooting from CZ99 - 9mm caliber pistol by the students of ACPS at the distance of 10 m from standing position, it has been determined that there is statistically significant connection between various mechanical characteristics of extensor muscle force of back-waist musculature, leg extensors and both hands finger flexors at the level of 83.5% with the evaluation error of 10.36%. The mechanism for regulation of force intensity and excitation of motor units of extensors of back-waist musculature is responsible for the stability of the position of upper part of the body up to the interval of 200 milliseconds, while the same mechanisms of leg extensors undertake the function of correcting the position in the interval from 200 to 900 milliseconds. The mechanisms for regulation of the force level and intensity (F and RFD) both play the dominant role for the finger flexors, as well as the excitation of motor units (K_f) in the interval up to 120 milliseconds [5]. It is interesting that these data completely concur with the data of Shadner and associates [21] who determined that the control of correction of hand position by muscles responsible for the movement is done by closed system of the respective motor program within the time interval of about 120 milliseconds.

In situations typical for police and military line of duty performed in the field there is a wide range of load, from the aspect of reaction of surface force which the leg muscles have to overcome in relation to solving of various motor actions realized by the given task [28]. The sample of eight soldiers was used to measure the reaction of surface force in five /5/ characteristic situations, i.e. walking, sudden changes of direction for 180º, running, vertical leaps and jumps from the height of 0.85 m. It has been shown that the level of loading (maximum values expressed per one kg of body mass of a tested individual) is the highest for running (617 N kg^{-1} s^{-1}), then for jumps (454 N kg^{-1} s^{-1}), vertical leaps (383 N kg^{-1} s^{-1}), sudden changes of direction for 180º (226 N kg^{-1} s^{-1}), and the lowest for walking (93 N kg^{-1} s^{-1}). Converted into absolute values (average BM of a tested individual was 78.44 kg) maximum (peak) force of surface reaction was 4935 daN for running, 3631 daN for jumps, 3063 daN for leaps, 1808 daN for sudden changes of direction and 744 daN for walking. Based on these data it can be concluded that completion of specific motor tasks related to polygon requires the fitness of actual musculature for a wide range of force loading (from 4935 daN to 744 daN standardized per second of manifestation).

The coordination between the level of activation of primary motor cortex and specific motor tasks is higher in situations of dynamic manifestation of a movement than in situations of control by isometric strains, i.e. when the level of force required to perform a particular task is fixed [12]. This only points to the significance of influence of mechanical characteristics of muscle group force which is dominantly loaded/participated in performing motor task defined by SPSP.

On the basis of the results it can be concluded that when solving complex police situational tasks lasting up to 90 seconds during which it is necessary to shoot from the fire arms, the efficiency of shooting at the probability level higher than 90% depends on the ability of muscles of legs and beck-waist musculature to set the body into a stable position within the time interval of about 95 to 200 milliseconds, as well as on the right hand finger flexors which hold and position the weapon in the direction of target and perform discharge, providing in this way the conditions for precise discharge up to the time interval of about 1010 milliseconds.

Among predicting variables of the defined mathematical model which statistically significantly at the level higher than 80% describe the criterion, there are several variables set out which belong to various spaces, i.e. various physical characteristics such as: energy potential of the body with the measure of aerobic power (VO_{2rel}); speed of locomotion with the measure of fitness for realization of maximum intensity effort performed in the aerobic mode (V_{crit}); specific dexterity with the measure of basic manipulation with fire arms ($MANIP_{weap}$); and contractile muscle characteristics which are controlled by the mechanisms for regulation of manifestation of the level of the acquired force of back-waist musculature muscles ($Dead_{LIFT}F_{max30\%}$ and $Dead_{LIFT}F_{max100\%}$), as well as the intensity of force realization in the function of the given/required time interval of left hand finger flexors ($HG_{L}F_{max50\%}$) – Table 2.

The results indicate that within the next level of probability, the efficiency of shooting (at the probability level higher than 80% during the given effort) depends on the ability of the body to spend between 50 and 58 milliliters of oxygen per minute per kg of body mass at maximum performance in aerobic mode, and that the intensity of performance at the critical speed can be realized at the speed between 4 and 4.45 meters per second (Table 1). In relation to world norms for indicators of aerobic power for the given age the level of fitness of the sample can be defined as good (from 51 to 56 ml/kg/min is standard for good fitness, 56-63 ml/kg/min for very good, and over 63 ml/kg/min for excellent in relation to the males of 20 years of age) [22]. Those tested who could perform a strain of 7 manipulative activities as a measure of specific ability of handling fire-arms [4] within the time interval of 5.6 to 8.4 seconds could also manage the defined tasks with the higher level of efficiency. Such a connection refers to the fact that the higher level of training of fire-arms manipulation in peace provides the higher quality specific motor basis for more reliable and efficient fire-arms manipulation during specific police situations where there is a need to use weapons during physical effort.

At the level of probability, in order to provide the conditions for stable body position, the muscles of back-waist musculature must be developed, i.e. the level of force of about 50 to 167 DaN (from 50.9 to 170.3 kg) must be acquired, which depends on the body mass of the tested and the speed at which someone approaches the given shooting position and on the kinetic force the body must overcome when stopping. The time interval within which the said force levels are reached, i.e. analogue to the period required to establish the given position, is about 94 to 2375 milliseconds.

In relation to the lowest level of probability of 70% which statistically significantly defines the criterion by this model, i.e. the efficiency of use of fire arms in the observed situation depends on the ability of the body to develop absolutely maximum speed of linear locomotion (RUN_{20m}), as well as to acheive a highly developed level of energetic efficiency of body functioning under aerobic strains ($ENERG_{effic}$) (Table 2).

On the basis of the results it can be concluded that during the given effort, the shooting efficiency at the probability level higher than 70% depends on the ability, i.e. potential of the body during the maximum effort of linear running to reach the speed of 7.23 to 8.15 meters per second, as well as to realize the total movement/general locomotion at the energetic efficiency index ranging from 51.30 to 58.50 (Table 2).

It is known that the time of reaching the level of maximum oxygen consumption directly depends on the intensity of work in the function of its duration. If you work at the maximum possible intensity, which can be realized within various time intervals from 60 to 560 seconds, you always reach the level of functional body load which provokes the body response for maximum oxygen consumption [3]. The efficiency of work, both from the mechanical and energetic aspects, depends on what intensity of work for the given level of oxygen consumption the individual can achieve. Those students who could realize the higher critical speed for the given oxygen consumption (V_{crit}), in other words, those who could realize or stand the higher load intensity for the given time interval defined by the length and duration of solving the task at the SPSP, had a better functional basis (in terms of aerobic function of the body) to complete the polygon in shorter time. Although the speed of polygon completion was on the average 32.31% of the critical running speed at the athletic track, and from that aspect one could have an impression that during performance of the polygon task there was not a high value of functional body loading achieved, the structure of additional tasks (crawling, jumping over, jumping on, bending, postures, aiming, etc.) as specific police motor loads caused very high additional energy consumption which exceeded 10 $kcal \cdot min^{-1}$ (40 $kJ \cdot min^{-1}$) [3].

Also the increase of energy requirements during performance of polygon tasks was caused by the surface on which the students moved. This statement is supported by the fact that the energetic efficiency of movement directly depends on the hardness of the surface on which they move or run. Running on soft surfaces (soil, grass, peat, sand…) is by about 12% energetically less efficient than on hard surfaces (concrete, asphalt…). This can be explained by disperse mechanisms, i.e. the decrease of surface reaction force and its reverse influence over elastic muscle components [11].

Rather a small number of researches available in literature have dealt with the shooting situations within the framework of complex motor tasks during continuous physical loading. One of the researches found in the available literature deals with the dexterity of shooting during biathlon race and examines the differences of manifested dexterity in elite and intermediate competitors [20]. It shows that the shooting efficiency, as well as the time required to make a decision on pulling the trigger does not differ between the examinees when the testing is performed in peace, but that there are statistically significant differences between the examinees after the physical load which simulated competing conditions. In case of fatigue by the intensity identical to competing conditions, the elite biathlons showed the decrease in precise shooting efficiency and time needed for preparation and pulling the trigger for 26.67%, while there was a decrease of the said characteristics of 44.00% at intermediate competitors, which in total makes 39.39% difference in efficiency decrease of intermediate biathlons in relation to elite biathlons in the situation of competitors' fatigue.

This fact only confirms and leads to the conclusion that the students who possessed the higher level of aerobic energetic potential (VO_{2rel}, V_{crit}), and who moved energetically and mechanically more efficiently ($ENERG_{effic}$, and $MECHAN_{effic}$) had the advantage when compared with those whose potentials were less developed. This is why they completed the specific police tasks including shooting in a shorter time interval, i.e. on a higher level of efficiency in the function of time.

The results of many researches [18, 28, 32, 33] are in full compliance with the results of this study, i.e. that the various mechanical characteristics of force of basic muscle groups which take part in solving motor tasks on polygon (back-waist musculature, leg extensors and both hands finger flexors) significantly determine the success of individuals from the aspect of speed of completing the situation polygon. As the tasks performed at the SPSP represent very complex system of motor activities with the expressed requirements of body efforts and muscle control of movement over the aspect of manifested level of force, the intensity of manifested force and with permanent motor regulation of mechanisms inter and intra muscle control, the coordination of movement, it is obvious that the success in completion of SPSP depends on the manifested force characteristics which the examinees realize through the whole range of force-time relation curve (F-t relation).

This is why the statistically significant partial connection of the observed force parameters (F and RFD) of muscle groups responsible for movement and keeping of body posture (back-waist musculature and leg extensors) is established at the levels which define the first part of force-time curve (characteristic point of 30% of F_{max}), middle part of the curve (characteristic point of 50% of F_{max}), as well as the end of the curve (characteristic point of 100% i.e. F_{max}). The greater influence of the muscles of back-waist musculature in relation to leg extensors when describing criteria ($RB1_{effic}\%$) is probably the consequence of permanent movement in bent position and surmounting of obstacles where the manner of surmounting them determined the emphasized engagement of trunk musculature (horizontal bar and fence, crawling through the pipe, climbing grid, etc.)

CONCLUSION

The results of regression analysis (Table 3) show that the model of chosen predicting variable explains 11.79% of criterion space (adjusted R^2 - 11.79), i.e. the efficiency of use of fire-arms at SPSP when the lifting of targets is directed ($RB1_{effic}\%$). In other words, the results show that 11.79% of fire-arms shooting efficiency depends, in this case, on the motor abilities represented by the following physical characteristics: contractile abilities of tested muscle groups, locomotion speed, aerobic energy potential, general energetic efficiency of body functioning during effort and specific dexterity of handling fire-arms.

Based on the results it can be concluded that during the performance of complex police situational tasks which last up to 90 seconds in which period it is necessary to shoot out of fire-arms, the shooting efficiency at the probability level of 90% depends on the ability of leg muscles and back-waist musculature when setting the stable body position within the time interval of about 95 to 200 milliseconds, as well as right hand finger flexors which hold and position fire-arms in the direction of the target and pull the trigger, and in this way provide the conditions for precise discharge up to the time interval of about 1010 milliseconds.

Among predicting variables of the defined mathematical model which statistically significantly describe criterion at the level higher than 80% there are several variables set out which belong to various space, i.e. various physical characteristics. They are as follows: energetic potential of the body with the measure of aerobic power (VO_{2rel}); speed of locomotion with the measure of fitness to perform maximum intensity effort realized in aerobic mode (V_{crit}); specific dexterity with the measure of basic weapon manipulation ($MANIP_{weap}$); and contractile characteristics of muscles controlled by the regulation mechanisms of manifestation of the achieved force level of muscles which belong to the back-waist musculature ($Dead_{LIFT}F_{max30\%}$ and $Dead_{LIFT}F_{max100\%}$), as well as the intensity of force realization in the function of the given/needed time interval for the left hand finger flexors ($HG_LF_{max50\%}$) (Table 2).

In relation to the lowest level of probability of 70%, which statistically significantly defines criterion by the model, i.e. the efficiency of use of fire-arms in the observed situation depends on the capability of the body to develop absolutely maximum speed of linear locomotion (RUN_{20m}), as well as to possess the highly developed level of energetic efficiency of body functioning under aerobic effort ($ENERG_{effic}$) (Table 2).

The tasks solved at the SPSP represent a very complex system of motor activities which clearly require body effort from the aspect of contractility in relation to the whole potential defined by the force-time curve range (f-t relation), with the permanent motor regulation of mechanisms inter and intra muscle control, the coordination of movements, highly developed basic (aerobic) functional ability of the body, as well as the capability to establish maximum locomotion speed. On the basis of all the above said it can be concluded that this kind of specific police tasks requires the fitness level which can be achieved using training methods that would comprise the directed work on the development of particular physical characteristics and combined methods to develop several characteristics in an integral manner.

PRACTICAL APPLICATION

The results of this research indicate that, in order to make physical fitness of policemen function in a good way, it is necessary to use methods for developing of the following physical characteristics: all types of muscle force and strength, and especially velocity, explosiveness, both maximum and endurance in strength; method for developing of maximum speed of locomotion; method of developing of aerobic and anaerobic energetic body system. Besides, these methods are necessary in the basic physical fitness preparation, as well as in specific physical fitness preparation (use of the situational method during the training exercise). Moreover, the results have shown that application of the exercises that dominantly load the trunk musculature (back extensor and abdomen muscles), legs muscles, and arms muscles is necessary. The defined model of mathematical regression equation, i.e. the model of SPSP efficiency prediction, can be used as a random method, as a periodical indirect testing procedure for checking the situational pistol shooting efficiency at police officers.

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Address for correspondence:

Assis. Mr Sci Goran Vučković
Academy of Criminalistic and Police Studies, Department of Special Physical Education,
Cara Dušana 196
11080 Belgrade - Zemun, SERBIA
Phone: +381 11 3161 444 (office)
Fax.: +381 11 3162 150 (office)
E-mail: vuckotim@ptt.yu